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CAPPED IN-WATER DISPOSAL OF CONTAMINATED DREDGED MATERIAL BY THE US ARMY ENGINEER DISTRICT, SEATTLE

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ABSTRACT

The Seattle District and the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, are cooperating in a field demonstration study to evaluate the effectiveness of dumping contaminated dredged material in a subaqueous depression and capping it by slowly releasing sand from a bottom-dump barge. This discussion is limited to summarizing Seattle District's operational aspects, as WES data gathering and evaluation are still under way.

PROBLEM

The 6-mile (10-km) Duwamish Waterway, Seattle, Washington, (Figure 1) runs through an intensely heavy industrial and commercial area. A small shoal of contaminated material in the lower Duwamish Waterway significantly limits shipping drafts. When a waterway shoal becomes known, shipping agents tend to avoid scheduling fully laden vessels into that waterway, limiting first port-of-call shipping opportunities. Timely dredging with suitable disposal of the contaminated material presented a unique problem.

BACKGROUND

Lower Duwamish Waterway bottom sediments contain a variety of contaminants, including heavy metals, polychlorinated biphenyls (PCB's), Aldrin, and others. These contaminants preclude unconfined open-water disposal of dredged material. Nearby economical upland disposal sites for maintenance dredging have also have been unavailable in recent years. In order to reduce lower waterway shoaling, Seattle District, since 1978, has limited annual maintenance dredging to the relatively uncontaminated head of the navigation project, allowing it to perform as a settling basin.

PLANNING

Analyses of the shoaled sediment confirmed that the usual open-water disposal site in Elliott Bay could not be used due to the presence of heavy metals (Cu, 130 ppm; Pb, 190 ppm; Zn, 240 ppm; As, 22 ppm; Cr, 35 ppm) and organic material (Aldrin, 180 ppb) in amounts greater than local EPA criteria allowed. Later, during dredging, further analyses of the offending shoal sediment also determined the presence of PCB's (1.4-3.1 ppm).

After reviewing several disposal alternatives, Seattle District elected to pursue capping. Instrumental in selecting the capping option was WES's decision to conduct an 18-month program to monitor the dredging, disposal, and capping activities and obtain baseline data for use in field verification of

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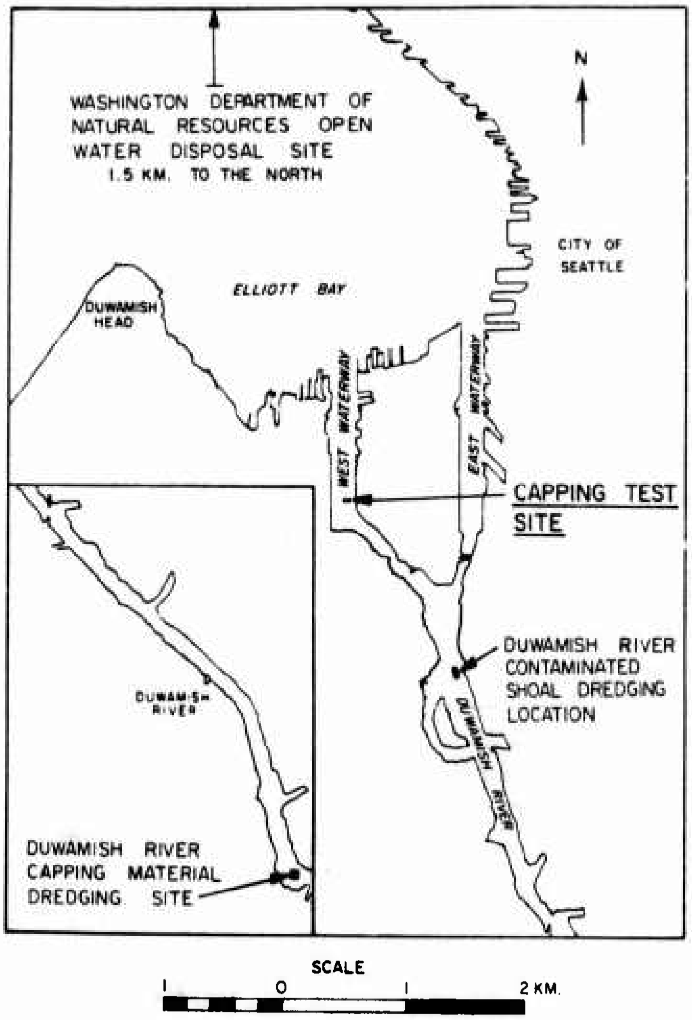


Figure 1. Duwamish Waterway

WES laboratory studies on the effectiveness of capping contaminated sediments. WES's commitment was in line with monitoring requirements of the environmental resource agencies.

DESIGN

Considerations included: locating an underwater depression or pit adequate to contain the contaminated material; determining properties of the dump site bottom material, shoal material, and capping material; determining methods and equipment for dredging and depositing the contaminated and capping materials; establishing a method of precise horizontal control for hydrographic surveys, placing and again finding underwater testing equipment, and positioning barges over dump locations; and investigating scour potential of the cap due to tidal velocities (Elliott Bay has an 11.3-ft (3.4-m) mean tidal range), river runoff, and ship propeller-generated currents.

A suitable capping site was found in the West Waterway, at the mouth of the Duwamish River. A depression approximately 75 ft (23 m) wide, 7 ft

(2.1 m) deep, 400 ft (120 m) long, and an average water depth of about 70 ft (21 m), running perpendicular to the waterway was found to receive the contaminated material.

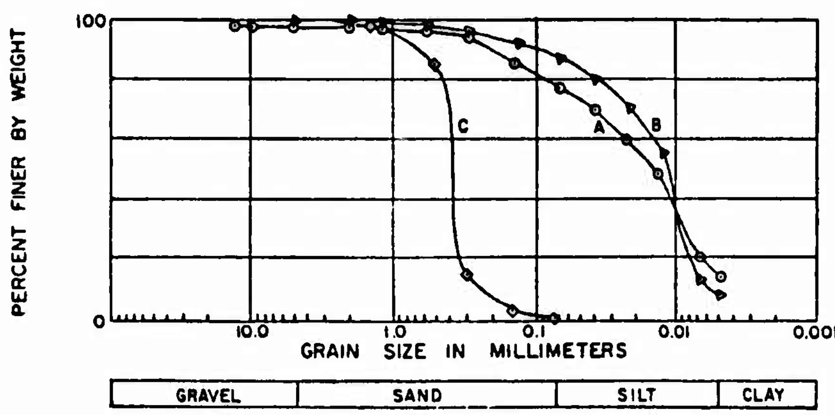
West Waterway bottom material, Duwamish Waterway contaminated shoal material, and upper turning basin sand capping material physical properties are shown in Figure 2.

A conventional clamshell dredge, split-hull bottom-dump barge, and tugs to transport and position the barge at the dump locations were selected for the work. The barge (Figure 3) was 180 ft (55 m) long with a 128-ft (39-m)-long hopper and a level capacity of 1,421 cu yd (1,085 cu m). Dredging of the shoal was limited to one bargeload to simplify the disposal operation and to reduce potential dispersion of the contaminated material beyond the depression.

The main concerns were the ability to dump the contaminated material squarely into the depression, visibility of the material on the hydrographic surveys, and that the depression would contain the lateral surge.

The contaminated material was to be capped by slowly (over the period of an hour) "sprinkling" clean sand from a bottom-dump barge, held in place with tugs. Survey profiles every 25 ft (7.6 m) perpendicular to the depression were selected to monitor material placement after each dump.

Surveyors from a warehouse rooftop on the south shore of the waterway up to 1,600 ft (490 m) away using a geodimeter and theodolite quickly communicated precise positions to personnel aboard boats in the waterway. Precise positioning was necessary to dump the barge of contaminated material directly over the center of the targeted depression. Barge positioning during sand



Sample	Location	Density of Material in place, gm/l	Void Ratio	Percent Organic Material	Classification	LL	PL	PI
A	West Waterway	2558	4.011	8.7	MH-Sandy Clayey Silt	54	34	20
B	Duwamish	2523	4.311	8.2	MH-Fine Sandy Clayey Silt	56	34	22
C	Upstream Basin	1999	0.717	2.19	SP-Sand	--	--	--

Figure 2. Physical properties of sediments

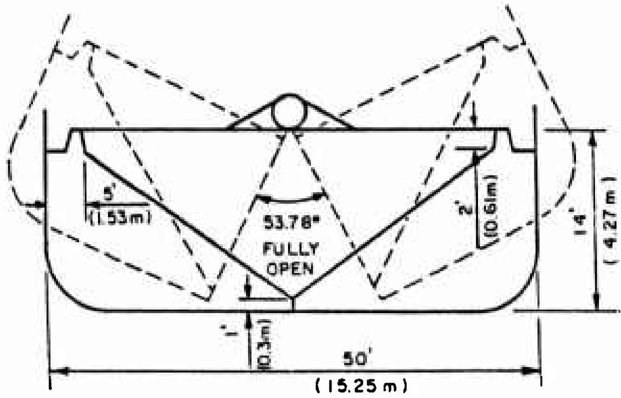


Figure 3. Split-hull barge section

capping was not as critical. Accurate control was required to position WES settling plates on the bottom (up to 75 ft (23 m) below the water surface) by divers, and to consistently locate them over the 18-month period. The vibracore bottom sampler had to be closely positioned to avoid damaging settlement plates. Visual shore ranges on dump centerlines were also used. Surveys were used to determine quantities of material dredged and placed, and will be used to monitor the cap in the future.

Potential scouring of the cap from runoff, tidal velocities, and ship propeller wash was found to be low.

DREDGING AND DISPOSAL

On March 26, about 1,100 cu yd (840 cu m) of contaminated fine, sandy, clayey silt was dredged by clamshell and carefully placed into a bottom-dump barge. The following day the barge was precisely positioned by geodimeter over the selected depression in the West Waterway and at slack tide quickly was dumped in about 72 ft (22 m) of water. During the dump the barge was barely cracked open when the fine-grained material liquified and flowed out of the barge in approximately 19 sec (from when material visibly started unloading until the barge was empty). Bottom impact was quite violent as four of five dual-anchored steel settling plates 4 ft by 4 ft by 1/2 in. (1.22 m by 1.22 m by 1.27 cm), weighing about 350 lb (159 kg) were overturned. One plate was moved about 45 ft (13.7 m).

Capping was done by slowly (about 27 cu yd/min (21 cu m/min)) bottom-dumping at slack tides about 4,200 cu yd (3,220 cu m) of clean sand, dredged from the head of the Federal navigation project. It was completed March 30.

Hydrographic surveys before and after each dump allowed monitoring and selective dump placement in capping the contaminated material. A small amount of the contaminated material appeared to have surged out of the depression after impacting on the bottom. Adjustments in cap placement were made to cover it. The cap (Figures 4 and 5) was placed with three barge dumps (same barge as was used for the contaminated material) over a 3-day period. Two to three dump locations were used for each bargeload of cap material.

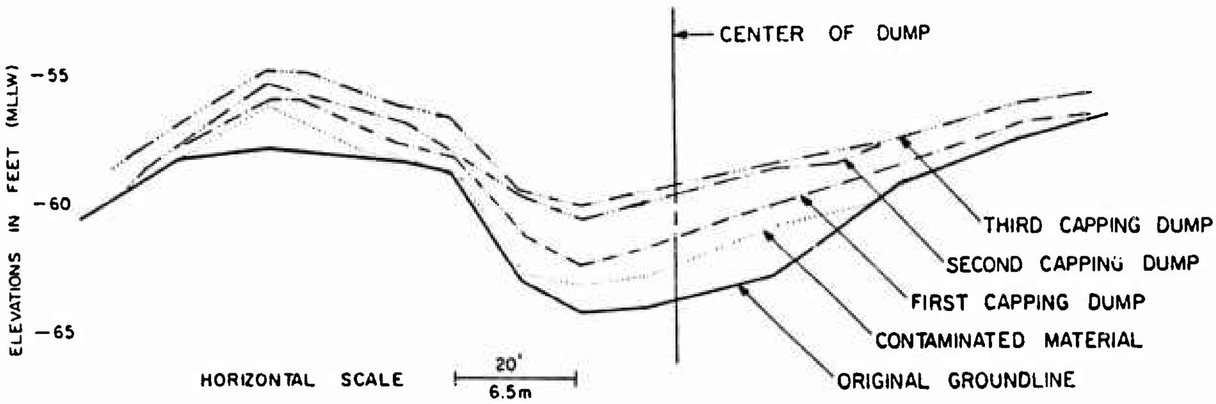


Figure 4. Section at center of dump (view is to east)

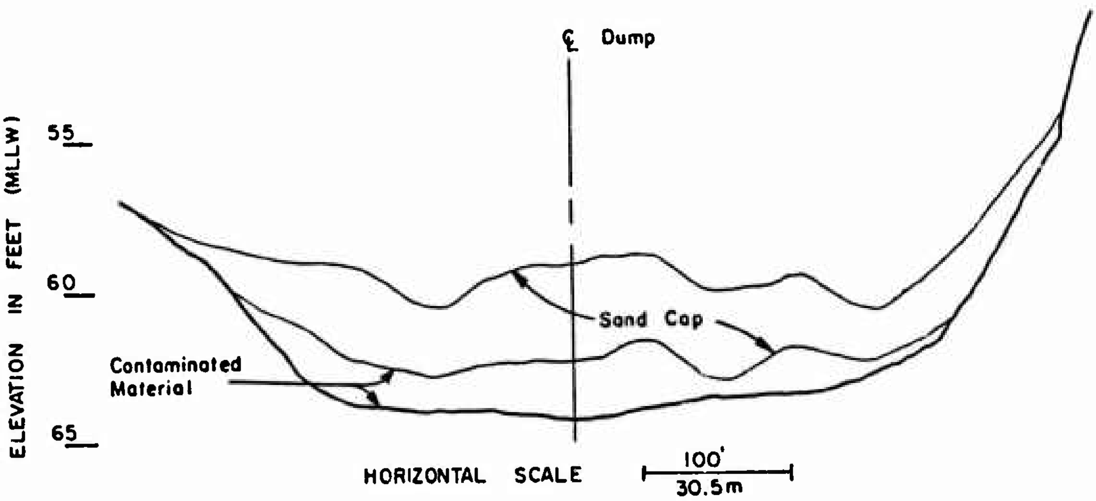


Figure 5. Section at center of dump (view is to north)

Survey data indicated a mean cap thickness of 2 ft (0.61 m) with a standard deviation of 0.78 ft (0.24 m) covering the contaminated material. This does not take into account an estimated 3 to 4 in. (7.6 to 10.1 cm) of settlement in the contaminated and bottom material within 5 days after capping was completed. The dredged and disposed volumes compared well for both contaminated and capping materials. The small volumes of contaminated and cap materials make it difficult to accurately determine quantities. WES core sampling, testing, and other field data are expected to refine the surveyed cap thicknesses.

Surveys and quantity computations were complicated by the intermittent appearance of a fluff layer on the bottom of the Duwamish Waterway up to 4 to 6 in. (10 to 15 cm) thick.

PRELIMINARY CONCLUSIONS

Only preliminary conclusions, mainly derived from Seattle District's physical operations, can be presented until the WES study with its broader evaluation is completed. These preliminary conclusions are:

a. Conventional dredging equipment and disposal techniques can be effectively used to dispose of dredged material in capping. The "sprinkling" technique of slowly releasing sand from a split-hull barge can be successfully used to adequately cap a given area.

b. Standard survey equipment and survey control are necessary and are adequate to precisely dump on target. Hydrographic survey information from conventional surveys provides considerable information and serves as a valuable monitoring tool.

c. The cohesive fine-grained material rapidly emptied out of the barge and quickly moved to the bottom as a unit with considerable energy. Disposal is not significantly affected by currents in the water column except in dispersing suspended sediments.

d. Relatively shallow depressions with steep side slopes appear to significantly reduce the outward surge of dumped cohesive dredged material.

e. With slow release of capping sand, displacement of soft, fine-grained material being covered appears to be minimal and one need not delay capping until the soft material is sufficiently consolidated to avoid displacement. Also, initial consolidation is quickly effected. These conclusions are based on field observations and need to be confirmed by WES lab test results.

f. Slow barge-dump placement of the sand cap may not be as accurate as with specialized equipment (i.e., placement by barge-mounted diffuser held near the bottom, etc.), but with sufficient cap material available and with good control, it can be used effectively and inexpensively.

g. "Sprinkling" of sands may wash out fine materials which may settle on top of the sands or may move with the current. This can be confirmed by WES testing.

h. Tugs need to be adequately powered to keep barges on target while dumping.

i. Resource agencies responded very quickly to the need to dredge the waterway and to the fully documented procedure for accomplishing the prototype capped disposal and subsequent monitoring. Agencies are very concerned about the precedent established by such disposal.